CLAIMS

What is claimed is:

1. A process for designing a mass separator comprising:
providing mass separator electric field data comprising data sets including mass separator geometric parameters and corresponding expansion coefficients, wherein the expansion coefficients comprise at least octapole and dodecapole expansion coefficients;
selecting a range of the data sets, the range comprising mass separator geometric parameters that correspond to positive octapole coefficients and least negative dodecapole coefficients; and
designing a mass separator comprising a geometry within the range of geometric parameters.

2. The process of claim 1 wherein the mass separator electric field data comprises ion trap electric field data.

3. The process of claim 2 wherein the ion trap comprises a cylindrical ion trap.

4. The process of claim 1 wherein the providing comprises numerically calculating the data sets from using $A_{2n} = \left[\frac{-2}{r_0^{2n}(2n)!} \sum_{j=1}^{\infty} \frac{(x_j r_0)^{2n-1}}{\cosh(x_j z_0) J_1(x_j r_0)} + \delta_{n,0} \right] V_{ring}$.

5. The process of claim 1 wherein the mass separator geometric parameters comprise r_0 and Z_0 parameters.

6. The process of claim 1 wherein the mass separator comprises an ion trap, the dodecapole coefficients are positive, and the geometric parameters further comprise an electrode spacer maximum value which provides a maximum spacing distance between electrodes of the mass separator.

7. A process for designing an ion trap comprising:

providing a range of data pairs individually comprising a Z_0/r_0 ratio and a corresponding spacing intermediate electrodes of the ion trap;

selecting a desired r_0;

selecting at least one of the data pairs from the range; determining a Z_0 value using the selected Z_0/r_0 ratio and the selected r_0; determining electrode spacing from the selected r0 and the selected spacing; and

designing a mass analyzer comprising the selected Z_0/r_0 ratio and the determined electrode spacing.

8. The process of claim 7 wherein the providing the range of data pairs comprises providing the data pairs individually comprising a Z_0/r_0 ratio and the corresponding spacing comprising a spacer maximum factor, and further comprising multiplying the selected r_0 by the selected spacer maximum factor to provide the selected spacing.

9. A method of producing a mass separator comprising:

providing first and second sets of components, individual ones of the components comprising a surface; and

aligning, in a cross section, the surfaces of the first set of components to oppose each other and the surfaces of the second set of components to oppose each other, the surfaces of the first set of components and the surfaces of the second set of components defining a volume, the volume comprising a first distance corresponding to a half a distance intermediate opposing surfaces of the first set of components and a second distance corresponding to a half a distance intermediate opposing surfaces of the second set of components, wherein, a ratio of the first distance to the second distance comprises from about 0.84 to about 1.2.

10. The method of claim 9 wherein the first component comprises at least one end cap of an ion trap.

11. The method of claim 9 wherein the first distance comprises Z_0.

12. The method of claim 9 wherein the second distance comprises r_0.

13. The method of claim 9 wherein the first distance comprises Z_0 and the second distance comprises r_0.

14. The method of claim 9 wherein the second component comprises a ring electrode of an ion trap.

15. The method of claim 9 wherein the surfaces of the first components are orthogonally related to the surfaces of the second components.

16. A method for producing an ion trap comprising:

providing an ion trap electrode body having an opening extending from a first end of the electrode body to a second end of the electrode body, the ion trap electrode body having a length extending from the first end to the second end, wherein the opening comprises a radius and the length comprises a center;

providing at least a first ion trap electrode end cap comprising a surface; and

aligning the first ion trap electrode end cap surface over and opposing a first surface of the electrode body adjacent to the first end, the first ion trap electrode end cap surface provided a distance from the center of the ion trap electrode body length, wherein a ratio of the radius to the distance is from about .84 to about 1.2.

17. The method of claim 16 wherein the ion trap comprises a cylindrical ion trap.

18. The method of claim 16 wherein the first end cap electrode comprises a solid material having a centrally located aperture.

19. The method of claim 16 wherein the first end cap electrode comprises mesh.

20. The method of claim 16 further comprising:

providing a second ion trap electrode end cap comprising a surface; and

aligning the second ion trap electrode end cap surface over and opposing a second surface of the electrode body adjacent to the second end, the second ion trap electrode end cap surface provided the distance from the center of the ion trap electrode body length.

21. The method of claim 16 wherein the second electrode cap comprises a solid material having a centrally located aperture.

22. The method of claim 16 wherein the second electrode cap comprises mesh.

23. The method of claim 16 wherein the ratio has an associated spacer maximum factor and the mass separator further comprises an electrode spacing between the end cap surface and the electrode body surface and corresponding spacer maximum value.

24. A method for producing an ion trap comprising:

aligning an ion trap electrode body and ion trap end caps;

providing the ion trap end caps spaced a first distance of $2Z_0$ apart, the ion trap electrode body having ends adjacent the end caps and being centrally aligned between the ion trap end caps and comprising an opening having a radius of r_0 and a half height comprising a second distance from the center to the end of the ion trap body, the end caps being spaced from the ion trap electrode body ends by an electrode spacing comprising Z_0 less the half height; and

wherein a ratio of Z_0/r_0 has an associated spacer maximum factor and the electrode spacing is less than a product of the spacer maximum factor times the r_0.

25. The method of claim 24 wherein the ion trap comprises a cylindrical ion trap.

26. The method of claim 24 wherein the ion trap end caps comprise stainless steel.

27. The method of claim 24 wherein the ion trap end caps comprise a solid material having a centrally located aperture.

28. The method of claim 24 wherein the ion trap end caps comprise mesh.

29. The method of claim 24 wherein the Z_0/r_0 ratio and the associated spacer maximum factor comprise rows of:

Z_0/r_0	Spacer Maximum Factor
0.84	0.08
0.86	0.16
0.88	0.22
0.90	0.26
0.92	0.30
0.94	0.33
0.96	0.36
0.98	0.39
1.00	0.42
1.02	0.45
1.04	0.47
1.06	0.50
1.08	0.52
1.10	0.55
1.12	0.57
1.14	0.59
1.16	0.62
1.18	0.64
1.20	0.66.

30. A mass separator comprising first and second sets of electrode components, individual ones of the components comprising a surface, wherein, in a cross section, the surfaces of the first set of components oppose each other, the surfaces of the second set of components oppose each other, and the surfaces of the first and second sets of components define a volume, the volume comprising a first distance corresponding to a half a distance intermediate opposing surfaces of the first of components and a second distance corresponding to a half a distance intermediate opposing surfaces of the second set of components, wherein, a ratio of the first distance to the second distance comprises from about 0.84 to about 1.2.

31. The mass separator of claim 30 wherein the mass separator comprises an ion trap and the surface of the first component comprises the surface of at least one of the end caps of the ion trap and the surface of the second component comprises the inner surface of the ring electrode of the ion trap.

32. The mass separator of claim 31 wherein the ion trap comprises a cylindrical ion trap.

33. The mass separator of claim 31 wherein the end caps comprise stainless steel mesh.

34. The mass separator of claim 30 wherein the first set of components are orthogonally related to the second set of components.

35. A mass spectrometer comprising:

a sample inlet;

a mass separator configured to receive at least a portion of a sample from the sample inlet, the mass separator comprising first and second sets of electrode components, individual ones of the components comprising a surface, wherein, in a cross section of the mass separator, the surfaces of the first set of components oppose each other, the surfaces of the second set of components oppose each other, wherein the opposing surfaces of the first and second sets of components define a volume comprising a first distance corresponding to a half a distance intermediate opposing surfaces of the first set of components and a second distance corresponding to a half a distance intermediate opposing surfaces of the second set of components, wherein a ratio of the first distance to the second distance comprises from about 0.84 to about 1.2; and

a detector configured to receive and detect ions from the mass separator.

36. The mass spectrometer of claim 35 wherein the sample inlet comprises a capillary membrane.

37. The mass spectrometer of claim 35 wherein the mass separator is configured to ionize at least a portion of the sample and separate at least a portion of the ionized sample.

38. The mass spectrometer of claim 35 wherein the mass separator comprises an ion trap.

39. The mass spectrometer of claim 38 wherein the ion trap comprises a cylindrical ion trap.

40. The mass spectrometer of claim 39 wherein the surface of the component of the first set of components comprises an inner surface of the at least one of the end caps of the cylindrical ion trap and the surface of the component of the second set comprises an inner surface of the ring electrode of the cylindrical ion trap.

41. The mass spectrometer of claim 40 wherein the end caps further comprise an opening.

42. The mass spectrometer of claim 41 wherein the end caps comprise stainless steel mesh.

43. The mass spectrometer of claim 40 wherein the opening is aligned with the volume center.

44. The mass spectrometer of claim 40 wherein the cylindrical ion trap further comprises an electrode spacing distance between individual ones of the end caps and the ring electrode, wherein the electrode spacing distance is related to the ratio.

45. The mass spectrometer of claim 35 wherein the electrode spacing distance is related to the ratio by a spacer maximum factor.

46. The mass spectrometer of claim 35 wherein the electrode spacing distance is less than the product of the spacer maximum factor times the second distance.

47. The mass spectrometer of claim 39 wherein the cylindrical ion trap comprises stainless steel.

48. The mass spectrometer of claim 35 wherein the detector comprises an electron multiplier detector.

49. An ion trap comprising:

a body having a length and an opening extending from a first end of the body to a second end of the body, the length having a center portion;

a first end cap adjacent to the first end of the body, the first end cap having a surface proximate the first end and spaced a distance from the center portion;

a second end cap adjacent to the second end of the body, the second end cap having a surface proximate the second end and spaced the distance from the center portion; and

wherein the body and end caps define a volume between the surfaces of the first and second end caps and within the opening, the volume comprising the distance and a radius of the opening, wherein the ratio of the radius to the distance is from about 0.84 to about 1.2.

50. The ion trap of claim 49 wherein the body and the end caps comprise stainless steel.

51. The ion trap of claim 49 wherein the ion trap comprises a cylindrical ion trap.

52. A mass spectrometer comprising:

at least two mass separators in tandem, at least one of the two mass separators comprising an ion trap having a Z_0/r_0 ratio between 0.84 and 1.2.

53. The mass spectrometer of claim 52 wherein the mass separators are placed in series.

54. The mass spectrometer of claim 52 wherein the mass separators are placed in parallel.

55. The mass spectrometer of claim 52 further comprising an ion source and wherein the mass separators receive ions from the ion source.

56. The mass spectrometer of claim 52 wherein both the mass separators comprise ion traps.

57. The mass spectrometer of claim 52 wherein the ion traps individually comprise a cylindrical ion trap.

58. The mass spectrometer of claim 52 wherein the tandem mass separators have different r_0 parameters.

59. The mass spectrometer of claim 58 wherein the tandem mass spectrometers both have Z_0/r_0 ratios from about 0.84 to about 1.2.

60. The mass spectrometer of claim 52 further comprising at least two ion sources providing ions to the at least two mass separators.

61. An analysis method comprising:

ionizing a sample to be analyzed to produce an analyte having a mass/charge ratio;

transferring the analyte to a mass separator comprising first and second sets of electrode components, individual ones of the components comprising a surface, wherein, in a cross section, the surfaces of the first set of components oppose each other, the surfaces of the second set of components oppose each other, and the surfaces of the first set of components and the second set of components define a volume, the volume comprising a first distance corresponding to a half a distance intermediate opposing surfaces of the first set of components and a second distance corresponding to a half a distance intermediate opposing surfaces of the second set of components, wherein, a ratio of the first distance to the second distance comprises from about 0.84 to about 1.2;

providing first voltages to the sets of components, the first voltages creating a first electric field within the volume, wherein the first electric field maintains the analyte within the volume;

providing second voltages to the sets of components, the second voltages creating a second electric field within the volume, wherein the second electric field ejects the analyte from the volume; and

detecting the analyte upon its ejection from the volume.

62. The method of claim 61 wherein the mass separator comprises a cylindrical ion trap and the surface of the first component comprises an end cap surface and the surface of the second component comprises an inner surface of a ring electrode.

63. The method of claim 62 wherein the cylindrical ion trap comprises stainless steel.

64. The method of claim 62 wherein the end caps comprise mesh.

65. The method of claim 62 wherein the end caps comprise solid material having a centrally located aperture.

66. The method of claim 61 wherein the providing of the first and second voltages maintains and ejects analytes having a single mass-to-charge ratio.

67. The method of claim 61 wherein the providing the first and second voltages maintains and ejects analytes having a range of mass-to-charge ratios.